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(54) Method and apparatus for reducing size of particulate solids in fluid medium.

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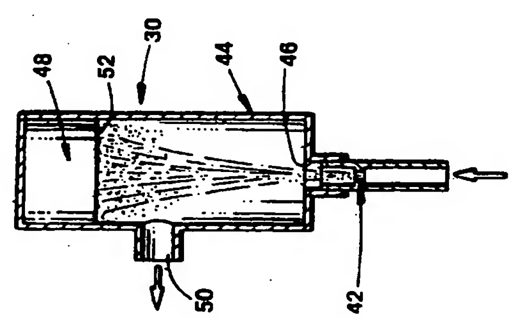

Fig. 2

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(54) **Method and apparatus for reducing size of particulate solids in fluid medium.**

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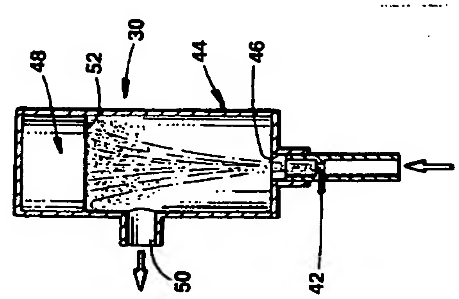

Fig. 2

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The present invention relates generally to a method and apparatus for reducing the size of particulate solids in a fluid medium, particularly but not exclusively, solids such as drill cuttings from a well bore.

The disposal of cuttings from the drilling of oil and gas wells has become an increasing problem. Environmental concerns, and governmental regulations reflecting those concerns, require the disposal of the cuttings in an environmentally sound manner. This disposal can be especially difficult where wells are drilled offshore. One method of disposal which is typically satisfactory is to return the cuttings to an existing subterranean well. Conventionally, this is often done through use of a grinder to grind the cuttings into relatively small particles in a slurry to facilitate introducing the ground particles into the well. The slurry is then pumped into the well through use of a high pressure pump.

In another known technique, as described in U.S. patent specification no. 5,109,933, a raw cuttings slurry of recovered drill cuttings in a carrier fluid is circulated through one or more specialized centrifugal pumps. U.S. patent specification no. 5,109,937 discloses the use of a particular configuration of centrifugal pump having an open channel between the fluid inlet and the blade tips; with the pump assembly modified to operate at a speed approximately fifty percent faster than the recommended pump speed for conventional applications. The action of the pump subjects the cuttings to shear, resulting in reduced size. Once the action of the modified centrifugal pump has sufficiently reduced the cutting particle size, the slurry containing the centrifugally sheared cuttings is utilized to convey the cuttings to a subsurface location.

These methods suffer from the disadvantage that they require large equipment useful solely to accomplish the particle size reduction. The use of a grinder, a large modified centrifugal pump or multiple centrifugal pumps, with the associated substantial manifolding and piping can require a significant amount of deck space on an offshore platform, for example, and can therefore present a significant disadvantage.

We have now devised a new method and apparatus for reducing the size of solids, such as drill cuttings, without reliance upon the shearing force of a centrifugal pump, which new method and apparatus further facilitates the particle size reduction in large part through use of equipment typically already present at the well location.

According to the present invention, there is provided apparatus for reducing the particle size of drill cuttings contained in a fluid medium, which apparatus comprises a primary pump for receiving and moving fluid medium containing said drill cuttings; a choke assembly arranged in the discharge path of said pump to receive fluid medium and said drill cuttings from said pump and to increase the velocity fluid and to impede the movement thereof; an impingement means cooperatively arranged with a choke for receiving the increased velocity mixture fluid and to impede the movement thereof.

The invention also provides a method of reducing the particle size of solids recovered from a wellbore, said solids being associated with sufficient liquid to be in a fluidizable state, which method comprises the steps of applying a pressure to said fluidizable solids to fluidize said solids and to impart a velocity thereto; and impinging said particles against a surface to stop the velocity thereof so as to induce breakage and particle size reduction of said solids.

An example of an apparatus in accordance with the present invention preferably includes a pressurizing assembly for receiving a volume of fluidizable solids. The solids will be fluidizable, preferably by being mixed with, or otherwise contained within, a suitable volume of liquid to establish a flowable raw cutting slurry. The pressurizing assembly, for example a relatively high pressure pump, will be utilized to further impart a velocity to the raw cutting slurry. In one particularly preferred embodiment, a conventional choke assembly will be utilized to further increase the established velocity of the slurry. The moving slurry will then be conveyed in such manner as to cause the slurry to strike a breaking or impingement assembly which will suddenly impede the movement of the solids within the slurry, thereby inducing breakage of the solids. In one particularly preferred embodiment, the fluids will be directed through a choke, as previously described, and will be allowed to strike a generally flat impingement surface several inches away.

The high pressure pump will preferably be utilized to apply pressure to the fluid sufficient in the system utilized to establish a velocity to the fluid sufficient to cover particle size reduction when travel of the particles thereby is impeded. In many applications the pressure applied to the slurry by the high pressure pump will preferably be in excess of approximately 300-500 psi (2.07-3.45 MPa); will further preferably be in excess of approximately 1,000 psi (6.89 MPa), and most preferably will be within the range of approximately 1,400-1,700 psi (9.6-11.7 MPa). These pump pressures may be adjusted in response to the size and composition of particles being treated.

In order that the invention may be more fully understood, reference is made to the accompanying drawings, wherein:

Fig. 1 shows schematically one example of a drill cutting particle size reduction apparatus in accordance with the present invention;

Fig. 2 schematically depicts one embodiment of choke chamber for the apparatus of Fig. 1;

Fig. 3 schematically depicts another embodi-

ment of a drill cutting particle size reduction apparatus in accordance with the present invention; and

Fig. 4 schematically depicts another embodiment of a choke chamber in accordance with the present invention.

Referring now to the drawings in more detail, and particularly to Fig. 1, therein is depicted an exemplary drill cutting size reduction apparatus 10 in accordance with the present invention; such apparatus adapted to reduce the size of drill cuttings and to inject the cuttings, such as through a wellhead, to a subterranean location. Drill cutting size reduction apparatus 10 includes a mixing tank 12 which will retain cuttings and a liquid carrier or process fluid during the cutting size reduction operation. In this preferred embodiment, drill cutting size reduction apparatus 10 includes a primer or booster pump 14 adapted to receive a slurry mixture from mixing tank 12 to pressurize the slurry for introduction into the suction end 16 of high pressure injection pump 18. The assembly of a mixing tank and a booster pump to facilitate removal from the tank may be a conventional skid-mounted assembly as is commonly present at a drill site.

High pressure injection pump 18 will supply the force actually utilized to "break" or reduce the cutting particle size. In the depicted embodiment, wherein a pressurized fluid supply to high pressure pump 18 is provided by booster pump 14, apparatus 10 includes a bypass conduit 19 past high pressure pump 18 to facilitate fluid returns to mixing tank 12.

The outlet side 20 of high pressure pump 18 is coupled to a manifold assembly, indicated generally at 22, which preferably includes first and second flow control valves 24 and 26. Manifold assembly 22 also preferably includes a conventional pressure relief valve 28 suitably arranged to relieve an overpressure condition in manifold assembly 22. First flow control valve 24 controls the passage of fluid from outlet side 20 of high pressure pump 18 to a choke chamber 30; the output of which 32 serves as an inlet to mixing tank 12. Second flow control valve 26 controls the passage of a slurry from the output of high pressure pump 18 to a collection location, such as a wellhead or other surface mechanism for communicating the slurry injection to a subterranean location.

In one particularly preferred embodiment, mixing tank 12 will be a conventional tank having a capacity of approximately fifty barrels, and will preferably include a conventional agitation or mixing assembly, as indicated schematically at 34. An appropriate conduit 36 will supply an effluent from mixing tank 12 to the inlet of booster pump 14. Booster pump 14 may be of any convenient design capable of pressurizing the slurry effluent from tank 12 to pressurize suction end 16 of high pressure injection pump 18. In one application, a 4 x 6 rubber-lined centrifugal pump manufactured by the Galligher Co. of Salt Lake City, Utah, has been found to be satisfactory. A rubber-lined pump is not necessary, but has been utilized for testing purposes, as it was least likely to induce breakage of the drill cuttings. The pump utilized pumped at a rate of approximately 15 barrels per minute (BPM).

High pressure injection pump 18 may be of virtually any appropriate and desired configuration. Injection pump 18 can be, and will preferably be, the same high pressure pump to be utilized for pumping the reduced particle size slurry into the subsurface formation. A model HT-400 pump, manufactured by Halliburton Services, Duncan, Oklahoma, pump has been utilized and found satisfactory. In test of the invention, the HT-400 pump was configured to pump a volume of approximately five barrels per minute (5 BPM) at a pressure of 1,500 psi. The outlet of booster pump 14 may be coupled to high pressure injection pump 18 through use of a "logger" header which facilitates providing the pressurized output of booster pump 14 to multiple inlets of suction end 16 of pump 18, while allowing excess to return through bypass conduit 19 to mixing tank 12. First and second flow control valves 24 and 26 are each preferably plug valves. For example, the Low Torque Plug Valves made by Halliburton Services, of Duncan, Oklahoma have been found to be satisfactory. Alternatively, flow control valves may be of any desired type, such as ball valves; or a three-way valve could be utilized in place of both valves.

In one preferred embodiment, the outlet conduit 40 coupled to outlet side 20 of high pressure pump 18, will have approximately a two inch internal diameter. In such configuration, each flow control valve 24, 26, and the related conduits will also preferably have an internal diameter of approximately two inches.

Referring now also to Fig. 2, therein is depicted the choke chamber 30 operatively coupled downstream of first flow control valve 24. Choke chamber 30 preferably includes a fixed diameter choke section, indicated generally at 42, coupled to a particle breaking chamber, indicated generally at 44. In the described exemplary embodiment utilized for test, a fixed choke having a ceramic-lined orifice with a diameter of 0.5 inches has been found satisfactory. In the described test of the invention, with high pressure pump pumping at a rate of approximately 5 BPM the velocity of the slurry through the choke was approximately 343 ft./sec.

Particle breaking chamber 44 is preferably a generally cylindrical chamber having an inlet 46 proximate one end and an impingement block 48 disposed longitudinally therefrom. A generally radial fluid exit 50 is preferably provided intermediate the length between inlet 46 and impingement block 48. Impingement block 48 includes a generally flat impingement surface, although many configurations of impingement surfaces may be envisioned. For example, convex and concave surfaces, or multiple surfaces

formed of rods or bars, or other structures, in chamber 44 are contemplated. In one preferred embodiment, particle breaking chamber 44 is approximately 4.5 inches in internal diameter and extends approximately fourteen inches from choke 42 to forward surface 52 of impingement block 48. Fluid outlet 50 of choke chamber 30 will extend to a conduit 32 providing return flow to mixing tank 12. In the described exemplary apparatus, the return flow to mixing tank 12 is provided through a two-inch conduit.

Operation of the disclosed apparatus 10 is as follows. The circulating or mixing mechanism 34 in tank 12 will be utilized to provide a slurry which will be selectively communicated to booster pump 14. Booster pump 14 will pull the mixed slurry of generally mixed drill cuttings and carrier fluid from tank 12 to provide a stable pressurized fluid source for high pressure injection pump 18. High pressure injection pump 18 will further pressurize the slurry, forcing the mixture through outlet conduit 40 and first flow control valve 24, and thereby through fixed choke 42. As a result of the forcing of the mixture through choke 42, the velocity of the mixture is increased to "fire" the mixture into surface 52 of impingement block 48. This results in breaking of the drill cutting particles. The partially reduced particle size slurry will be circulated through the system until such time as the drill cuttings are sufficiently reduced in size to facilitate introduction into the subterranean formation. At such time, first flow control valve 24 will be closed, and second flow control valve 26 will be opened, thereby facilitating the transfer of the reduced particle size slurry directly to a wellhead, or other appropriate assembly, for introduction into the subsurface formation.

In one exemplary test performed through use of the apparatus described herein, the process was tested relative to reducing the size of drill cuttings of which almost 50 percent of the sample had a particle size greater than 2,000 microns (0.0779 inch; or retained by a 10 mesh screen), with the largest measured particle being 0.72 x 0.48 x 0.03 inch. The particles of this latter approximate size made up approximately 2 percent of the total sample. Approximately 23 percent of the cuttings ranged in size between 10 and 20 mesh (between 2000 microns and 850 microns); with another substantial portion of the cuttings ranging between 20 and 60 mesh (between 850 microns and 250 microns); with the remainder of the particles being of smaller sizes.

As noted earlier herein, the process fluid may be any suitable and desired fluid, including, for example, fresh water, salt water and viscofied water. In a first of the tests, fresh water was used as the process fluid in the mixing tank, and after circulation of the fluid began, the graded drill cuttings were metered into the reservoir. The addition rate of the drill cuttings was approximately 2 cubic feet per minute. In the second of the two tests, the process fluid was water viscofied with Halliburton WG-11 Gel, at a mixture of approximately 60 lb./1,000 gallons.

At the conclusion of the first test, 100 percent of the particles passed through a 30 mesh (600 micron) screen, with 62.1 percent of the particles passing through a 400 mesh (38 micron) screen. At the conclusion of the second test, all samples were under 60 mesh (250 microns) in size, with 62.8 percent of the particles passing through a 400 mesh (38 micron) screen.

The two tests did not take into account circulation time, or the number of cycles of the mixture through the system. Particle size is believed to be a direct function of the number of cycles through cutting particle size reduction apparatus 10. In both tests, the drill cuttings in the reduced particle size slurry were sufficiently reduced in size to maintain the solids in suspension even without agitation of the slurry.

Referring now to Figure 3, therein is depicted an alternative embodiment of a drill cutting particle size reduction apparatus in accordance with the present invention, indicated generally at 60, and illustrated in schematic form. Particle size reduction apparatus 60 is similar to previously described apparatus 10, with the exception that apparatus 60 schematically depicts the use of a mechanical particle size reduction apparatus, such as a grinder, "shredder" or similar device 62 coupled to the output of booster pump 14 to reduce the size of any exceptionally large cuttings to assure that all cuttings transmitted through the high pressure pump and other equipment will be of a size which may safely be handled. Devices such as the Shredder or De-lumper devices manufactured by the Franklin Miller Company of New Jersey may be utilized. Shredder 62 will also serve the purpose of eliminating large stones or other foreign objects which might damage or otherwise impair the operation of particle size reduction apparatus 60.

Particle size reduction apparatus also includes a plurality of choke chambers 64, 66 and 68 coupled in series through conduits 65 and 67, with a return conduit 69 to mixing tank 12. These multiple choke chambers 64, 66, and 68 are utilized in place of the single choke chamber 30 in the embodiment of Fig. 1. Choke chambers 64, 66 and 68 may each have a uniform size choke or may have a graduation of size chokes. The sizes of the chokes should be selected to maintain an acceptable level of pressure drop across the combined choke chambers 64, 66, and 68.

Referring now to Fig. 4, therein is schematically depicted an alternative embodiment of an impingement assembly 70, in accordance with the present invention. Impingement assembly 70 includes a housing 72 defining an internal chamber 74 with a choke discharge 76 forming an inlet at one end of the chamber. A chamber discharge 78 is placed generally longitudinally opposite inlet 76. A number of reducing elements, such as metal balls 80 are placed in chamber

74. Fig. 4 depicts balls 80 as they might appear during operation, where the discharge from choke 42 urges the balls 80 toward the opposite end of chamber 74. Balls 80 may be of either a single size, or of varying sizes. If balls 80 are selected of a size smaller than fluid inlet 76 and fluid outlet 78, barrier members 82a and 82b, such as crossbars, may be provided therein to retain balls 80 within chamber 74. In operation, as the force of fluid from choke discharge 76 encounters balls 80, the balls should be caused to agitate as the fluid and drill cuttings are forced therethrough, thereby reducing the drill cutting size not only through impact, but also through the grinding action of the circulating and rotating balls.

Claims

1. Apparatus for reducing the particle size of drill cuttings contained in a fluid medium, which apparatus comprises a primary pump (18) for receiving and moving fluid medium containing said drill cuttings; a choke assembly (30) arranged in the discharge path of said pump (18) to receive fluid medium and said drill cuttings from said pump and to increase the velocity fluid and to impede the movement thereof; an impingement means (48) cooperatively arranged with a choke (42) for receiving the increased velocity mixture fluid and to impede the movement thereof.

2. Apparatus according to claim 1, wherein said primary pump (18) applies a pressure to said fluid containing said drill cuttings in excess of 400 psi (2.76 MPa).

3. Apparatus according to claim 1 or 2, further comprising a booster pump (14) cooperatively arranged with said primary pump (18) to apply an initial pressure to said fluid containing said drill cuttings at the inlet side (16) of said primary pump (18).

4. Apparatus according to claim 3, which comprises a mixing tank (12) for receiving said solids and a liquid, said tank comprising a system (34) for generally mixing said solids and said liquid to form a solids/liquid mixture; said booster pump being cooperatively coupled to said mixing tank (12) for receiving the solids/liquid mixture therefrom and applying a pressure thereto; said primary pump (18) being cooperatively coupled to said booster pump (14) to receive the pressurized solids/liquid mixture therefrom, said primary pump (18) having a suction side (16) and a discharge side (20); said assembly (30) comprising a choke chamber cooperatively coupled in selective fluid communication with said discharge side (20) of said primary pump (18), said choke chamber comprising a choke member (42) configured to increase the velocity of said solids/fluid mixture; the impingement means being adapted to receive the increased velocity solids/liquid mixture from said choke member (42), said choke chamber having an outlet (50) in fluid communication with an inlet (32) to said mixing tank (12); a first valve (24) at least partially providing selective fluid communication between said discharge side (20) of said primary pump and a collection location.

5. Apparatus according to claim 4, further comprising a manifold (22) operatively coupled to establish fluid communication between the output of said booster pump (14) and the suction side (16) of said primary pump (18), said manifold being configured to supply a pressurized supply of fluid to said suction side (16) of said primary pump (18) but to allow a bypass (19) flow of fluid, said bypass flow of fluid being in fluid communication with a fluid inlet to said mixing tank (12).

6. Apparatus according to claim 4 or 5, wherein said choke chamber comprises an elongated chamber extending relative to a longitudinal axis through said choke assembly (30), wherein said impingement means (48) comprise an impingement block proximate one end of said chamber.

7. A method of reducing the particle size of solids recovered from a wellbore, said solids being associated with sufficient liquid to be in a fluidizable state, which method comprises the steps of applying a pressure to said fluidizable solids to fluidize said solids and to impart a velocity thereto; and impinging said particles against a surface (52) to stop the velocity thereof so as to induce breakage and particle size reduction of said solids.

8. A method according to claim 7, wherein said fluidizable solids are pressurized by pumping the solids through a pump (18) to apply a pressure in excess of 1,000 psi (6.89 MPa) to said fluidized solids and to impart a velocity to said solids.

9. A method according to claim 8, comprising the step of further boosting the velocity of said fluidized solids by causing said pumped solids to be passed through a choke assembly (30).

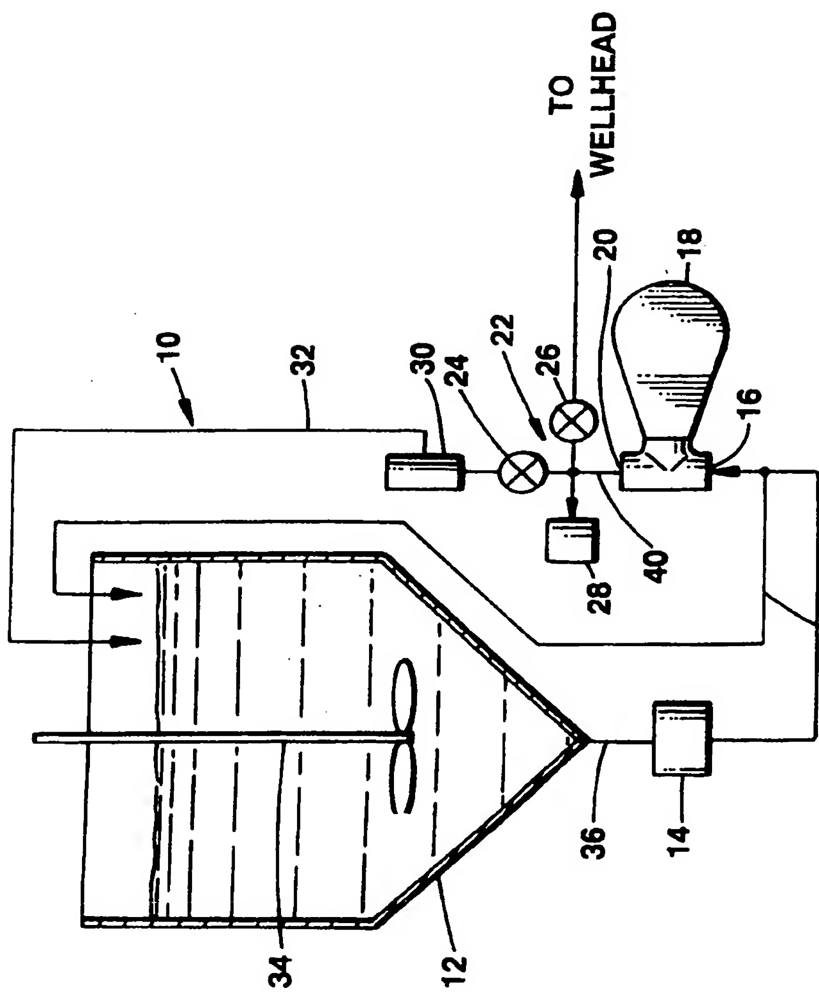
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Fig. 1

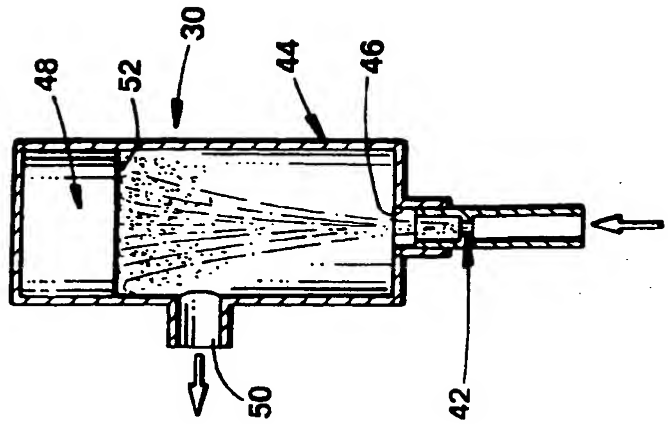
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Fig. 2

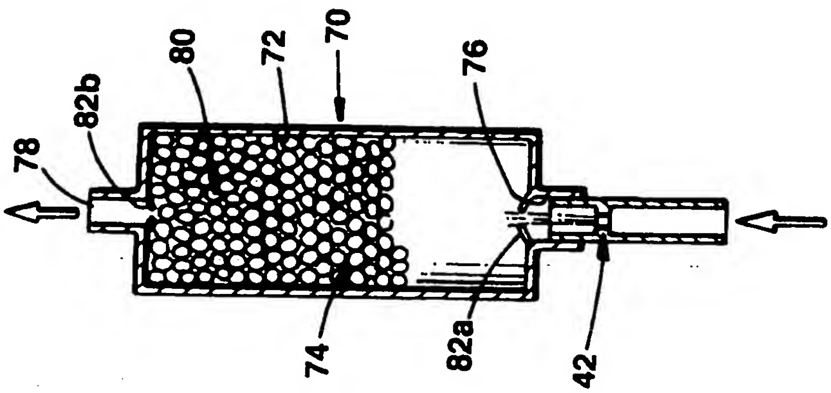
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Fig. 4

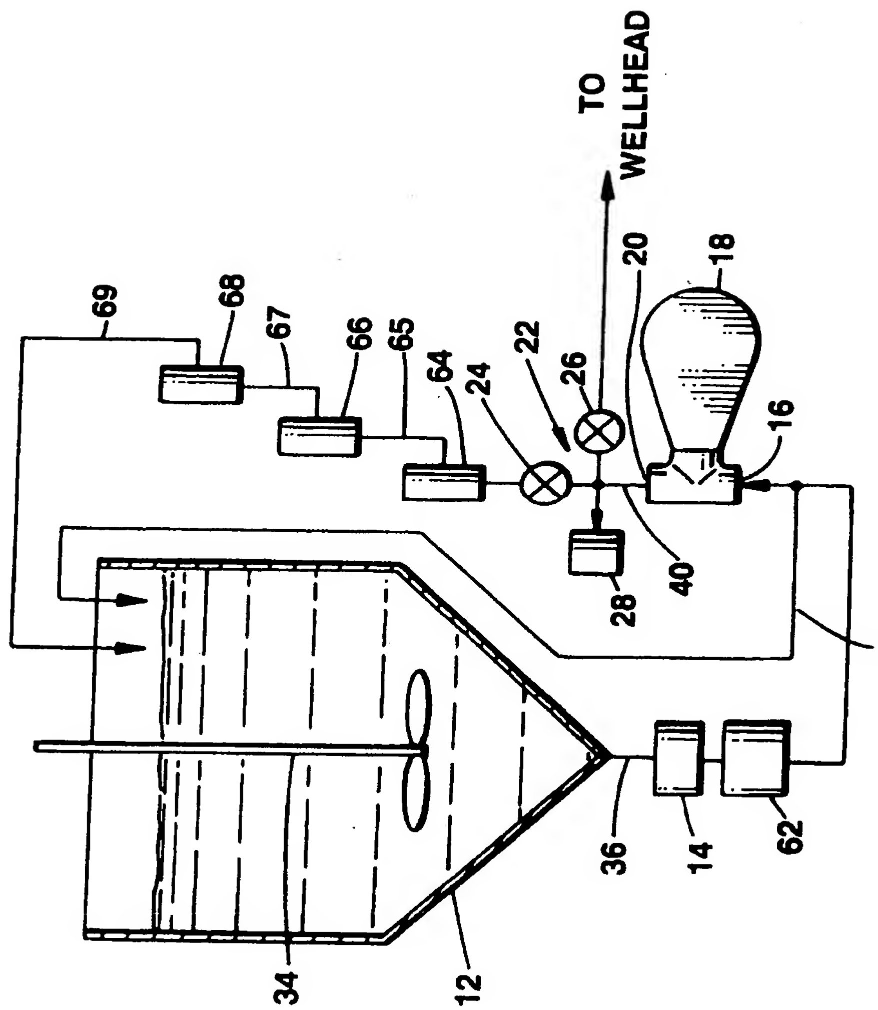
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Fig. 3

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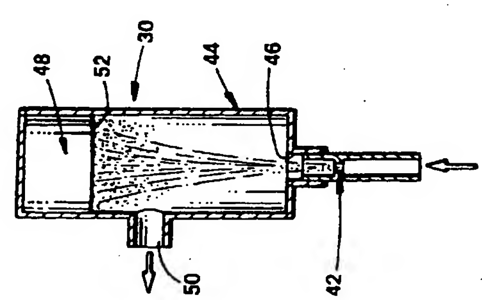

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 9257

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	FR-A-2 149 739 (LONE STAR INDUSTRIES) * figure 1 * ---	1-9	E21B21/06 B02C19/06
A	FR-A-2 243 737 (USS ENGINEERS AND CONS.) * page 8, line 1 - line 20; claim 2; figure 1 * ---	1-9	
A	EP-A-0 445 455 (MITSUBISHI) * figures * ---	1	
A	FR-A-2 661 450 (TOTAL) * abstract; figure 1 * ---	1	
A	US-A-3 831 352 (KEEN INDUSTRIES) * abstract; figure 3 * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

E21B
B02C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 November 1994	Fonseca Fernandez, H

CATEGORY OF CITED DOCUMENTS

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